INTRODUCTION
D. W. is a 19-year-old man with cerebral palsy, severe spastic quadriplegia and mental retardation. He would like to more fully participate in the paper-recycling project at Ashcroft Center. Due to the severity of his condition, he is not capable of sorting paper manually (he has no functional use of his upper extremities). In order for D.W. to sort paper, he needs a device that can be loaded with paper, will dispense the paper one sheet at a time, and will automatically turn each sheet over so that he can decide which pile to direct the paper into (blank on one side, or printed on both sides). This visual inspection job will also provide D.W. with an interesting cognitive challenge.

Two major designs are considered for this project. The first design is modeled after a locomotive wheel, with a gripper attached to move individual sheets of paper and to use the reflection from a mirror for viewing. The second design is of a “Paddle Wheel” nature. Essentially, one sheet of paper is dispensed into a paddle wheel so that D.W. can see it from his wheelchair, he hits a head switch to rotate the paddle wheel 90 degrees so that the paper can flip over and he can decide if the paper is printed on one side or on both sides. Once he decides which pile the paper goes into, he is able to use his head switch to control the direction the paddle wheel turns and deposit the paper into the correct bin. This sequence is repeated until all paper has been sorted.

SUMMARY OF IMPACT
The purpose of this project, “Paper Recycling,” is to create a vocational activity that a student with cerebral palsy, severe spastic quadriplegia, and mental retardation can participate in. D.W. has no functional use of his upper extremities, but is able to use dual head switches. The paper-recycling device is designed specifically for D.W., but may be used by anybody with similar disabilities.

At the Ashcroft Center, where D.W. is a student, paper is recycled for two purposes. Paper that is blank on one side is used to make scratch pads for nurses at various clinics and nursing homes. Paper that is printed on both sides is shredded and donated to companies to use as packing material. The anticipated impact of the “Paddle Wheel” design is that D.W. is now able to participate in the recycling of paper. As D.W. has no functional use of his upper extremities, it is the responsibility of the instructor to load paper into the tray, and once sorted, to unload paper from individual bins.

TECHNICAL DESCRIPTION
As is shown in Figure 17.1, the project consists of two assemblies, a paper dispenser and a paper separator.

Paper Dispenser: The paper dispenser loads one sheet of paper at a time (similar to a copier feed system). A tray is filled with assorted paper. The spring loaded is placed into a specially designed wooden box that contains a 12 volt D.C. motor, rollers, and a light sensor auto stop. The 12-volt motor is connected to a steel shaft containing two rubber rollers. When instructed by the student, the paper dispenser starts the feed process. The motor starts turning the rollers that pushes out an individual sheet. After the sheet passes through a laser beam, it shuts the motor off as it slides into a lexan paddle wheel. The short-range diffuse control is made by Allen-Bradley. Because of the high sensitivity and sharp cut-off of the laser beam sensor, it is ideally suited for space-limited applications where objects are to be detected and backgrounds ignored. This sharp cut-off diffuse type 42SRP series 6030 is much preferred over the use of a timed paper feed device. The diffuser allows for shorter or longer dispensing times that a specific timing device could not absorb. The student activates the paper feeder by a push or mouth control switch.

Paper Separator: The paper slides into the lexan assembly. The paper does not stick because an anti-static spray is used on the lexan paddles. The use of an aerosol such as “Static Guard” works quite well. The paddles are designed 45 degrees apart so that
paper cannot slide down or off the apparatus. The paddles are wide to allow for variability of the dispensing unit. The student can immediately identify through the lexan, if the paper is printed on the top surface. The student activates the switch to move the carousel clockwise in order to identify the other side. The paddle wheel rotates 90 degrees to allow the student to view the opposite side of the paper.

The student now knowing both sides of the paper can sort the identified paper into the scrap bin or to the recycled bin. The student has the ability, through switches, to send the paper fully clock or counter clockwise into the two bins. This process provides the student with positive decision making that is necessary for his rehabilitation. It also provides the student with a sense of accomplishment. The estimated cost of parts is $290.

Figure 17.1. Paper Recycling.
INTRODUCTION
A subject at the Rehabilitation Institute of Michigan has general weakness and low endurance resulting in balance and coordination problems during ambulation. The patient is at risk of falls and requires supervision and physical assistance for balance during standing and ambulation. The Occupational Therapist would like the subject to have a portable and adjustable adaptation to a standard wheelchair that allows appropriate body mechanics and functional use of the lower extremities in propelling a standard wheelchair. The design scope requires modification of a standard wheelchair to incorporate leg pedaling, which includes transferring the crank force to the back wheels by a common shaft that connects to the two back wheels. A provision is made for coasting when pedaling is discontinued. To enable portability, a provision is made to decouple the crank using an interlocking bolt between the crank and the linkage to the back wheels or the common shaft.

SUMMARY OF IMPACT
The subject has general weakness and low endurance resulting in balance problems during ambulation. The patient is at risk of falls and requires supervision and physical assistance for balance during standing and ambulation. The Occupational Therapist would like the subject to have a portable and adjustable adaptation to a standard wheelchair that allows for appropriate body mechanics and functional use of the lower extremities in propelling a standard wheelchair.

The anticipated impact is to facilitate strength production throughout the lower extremities, increase coordination and to increase general circulation and alternative mobility. It serves as both a physical and mental therapy while serving the subject as a means for limited ambulation.

TECHNICAL DESCRIPTION
The implementation is shown in Figure 17.2. The crank for recumbent cycling is coupled to a wheelchair by a crank extended and four bolts which run through the chair and the extender. The purpose of the extender is to support the crank and the pedals that are used to produce the crank force to drive the chair, and to allow for small adjustments in the location of the pedals. The use of a common bike crank and chair provides the drive or rotate the immediate shaft that rests on a pair of bearings. The use of the intermediate shaft is to accommodate the length of two chains and to produce a smoother transfer of the crank force to the back wheels. This intermediate shaft contains two freewheel sprockets that serve to transfer the pedaling force to the five speed sprocket that is connected to our common shaft. This five-speed sprocket then transfers our pedaling force to the back wheels by a common shaft that is connected to the back wheels. Power is only put to one of the back wheels to allow for steering by the use of hand brakes. The sensitivity analysis identifies the critical design parameters, and indicates whether the design constraints should be tightened or relaxed. In the present case, the length of the chain or the stiffness of the chain could be relaxed a small amount. This results in a reduction of noise. The load and the deflection analysis indicated the stiffness of the common shaft is important. The common shaft diameter is an important design parameter because it is the main weight-bearing component. The clearances of the chains are equally important, because it is where the drive force is being transferred. The compatibility analysis ensures that all components of the system work well with each other. In the compatibility analysis for the present project, interacting components and subsystems are reviewed to ensure members have matching design and operating parameters. Geometric compatibility of components ensured that configurations and sizes are compatible. To determine the compatibility of materials, the effects of dissimilar materials are investigated. Since conduit pipe, steel, and welding is planned to be used, the reaction between the two are reviewed and the team decided that their interaction in the present application is not detrimental. In designing the sub-systems, the connections between major components
are of concern. Having established the connections for the subsystems, the fits and tolerances for the connections of the major components are left to the final assembly stage.

The overall project is both challenging and enjoyable to design and produce. The chair itself and the design are extremely workable. The wheelchair is portable and allows for coasting when pedaling is discontinued. It is made to steer and produce leg strength and coordination with daily use. The main problem is making the chair adjustable to accommodate different heights of persons. This is due to the chains, you cannot adjust the chains easily to meet this requirement. The addition of links to both chains is time consuming and not cost effective, because of the number of chains required. The estimated cost of the system is $261.
INTRODUCTION
A 20-year-old young lady at the Northwest Wayne Skills Center has cerebral palsy with spastic quadriplegia, is legally blind, has a gross grasp and release with the left upper extremity and uses a wheelchair for mobility. This student wants to help prepare tri-folded mailings for a local car dealership and a Foundation. This entails stamping a bulk mail emblem in the upper right hand corner and stapling the bottom of the tri-folded paper. The student needs aids to help her locate the staple and stamp in their proper locations. The criteria for the design is that the device should consist of the stamp, stamp pad and electric stapler currently being used at the Skills Center. A device designed to help the student with her needs and satisfy the criteria would allow the student to be active and contribute to the community, thus raising her self-confidence.

SUMMARY OF IMPACT
The goal of the project is to develop a system to enable a student to ink a rubber stamp, stamp a bulk postage emblem and staple a u-i-folded piece of paper.

The system was developed to accommodate the existing stapling station, to fit the existing inkpad, and to satisfy the specific design objectives. The device can be used by either a left handed or right-handed person.

TECHNICAL DESCRIPTION
The following key issues were addressed before looking at design concepts. The student's range of motion is one of the most important considerations during the design phase. This includes the distance above the table top and from the body. The device should require little or no thinking to operate. As the student is legally blind, the device should have some color contrast to help her differentiate the key parts. Isometric strength and overall arm strength had to be considered. The student's strength is approximately 4 pounds (quantified by using a Measurand electronic force-measuring device). As far as basic hand motion, the student keeps her hand/ fingers in a ball with her forefinger pointing outward. Thus, a design that allows pushing and pulling with her hand in this natural state would be best as the student presents some shaking during movement.

In order to develop a functioning system, the following design specifications are considered. The device should help locate stapler and bulk stamp emblem in the proper location on u-i-folded paper. Aid the student in inking the rubber stamp. Incorporate usage of the electric stapler, rubber stamp and stamp pad used by the Northwest Wayne Skills Center; have some color contrast to help the legally blind student differentiate the key parts, be easy to use; be lightweight, and cost less than $800.

Two design concepts were evaluated. The first was to be made of steel, and had small parts that had to meet precise tolerances between members and would have been very time consuming to manufacture. Thus, the machine shop time and material caused this first design to be dropped due to cost. The second design concept utilized the same basic functional concepts as the first conceptual design, but was made out of wood, less expensive, and is more feasible for the student and teacher to use.

The system design required analyzing the pivot joint and calculating the stamp angle, spring constant, push/pull force of the sliding portion and force distribution along the arm. Analysis show that the rubber stamp should be positioned at 3.5 degrees to the horizontal, the pivot joint holding the stamp showed no failure when tested with a 15 lb. load, the necessary push-pull force to ink and use the stamp is about 1 lb. force, and the spring constant to support the pivot arm is 1.768 lb./in. Tests show the system performed as designed. The cost for the prototype material is approximately $275, without considering the wood shop time.
Figure 17.3. Tri-Fold Mailing Preparation Device.
Event Reminder

Designer: Thomas Kress
Supervisor: Bertram N. Ezenwa, Ph.D.
Departments of Physical Medicine and Rehabilitation and Mechanical Engineering
Wayne State University Detroit, MI 48202

INTRODUCTION
This design project is centered on a problem that one of the clients at the Rehabilitation Institute of Michigan has in regards to remembering when to take prescribed medication. The client has both diminished vision and hearing ability, which affects the ability to remember and complete timed medical routines. This includes remembering when to take prescription drugs, when to perform an exercise routine or any other timed activity. Currently, the client requires attendants to remind the individual of the timed task.

Most “Event Reminder” devices currently available signal the individual with an audible signal, usually a beeping tone. Some devices now available also visually signal the individual with a light. In summary, all the devices currently available rely on the individual’s vision or hearing ability. Since the client in this case does not possess well developed vision or hearing abilities, the purpose for this project is to provide some other method for reminding the client of a timed task without relying on sight or sound.

SUMMARY OF IMPACT
The goal of this project is to provide an Event Reminder device for a client with diminished vision and hearing abilities, who currently relies on attendants. The system provides for better outcomes from medication and independence for the client.

TECHNICAL DESCRIPTION
Two design concepts were considered. The first is a computer-controlled paging system that is too expensive to implement. The second design, shown in the figure, consists of an LCD Digital Timer (powered by a AAA battery), added leads and transistors, and a vibrator — all packaged in a single, plastic housing, which is affordable. This housing is mounted to the wrist with a small cloth wristband instrumented with Velcro.

The design process began with the Timer. The Timer, as purchased, contained a button cell-powered counter that drives an audible beeping component, a mini Piezo Buzzer. The Buzzer in the timing circuit is replaced by the Vibrator. However, the circuit would not operate in this condition due to the fact that, even though the voltage requirements are the same, the Vibrator required more current than the Buzzer. Quantitatively, the Vibrator required a minimum of 300 mA, while the Buzzer required less than 100 mA.

To remedy this situation, two revisions were made to the timing circuit. First, an oscillating component in the circuit designed to both lower the voltage to the Buzzer and condition the signal from the Counter. This is done because voltage requirements for the Vibrator (1.5V) are greater than that of the Buzzer (less than .1V), and the conditioned signal caused the Vibrator to operate inconsistently. The second revision to the timing circuit involved replacing the button cell on which the timer operated with a standard AAA battery, increasing the current available to the system.

While these revisions satisfied both the voltage and current requirements of the Vibrator, the circuit was still not operational. The timing circuit as designed activated the Buzzer by maintaining a constant voltage across the Buzzer when not in use, and lowering the voltage to the Buzzer to zero when activation is required. When the Vibrator is connected to this circuit, it is active at all times, except when the Timer counted down to zero, when it would stop. This is the opposite effect that is desired as far as Vibration operation is concerned.

A final revision to the tuning circuit was required. This revision involved replacing the circuit’s existing MOSFET transistor with a PNP transistor. This change accomplished two significant tasks. First, the signal to the Vibrator is inverted to operate the Vibrator as desired. Secondly, this new transistor allowed more current to pass to the Vibrator, allowing it to operate with more force.

This additional force enabled housing of the Vibrator within the plastic housing where it could be better
protected for a more robust design. Using additional power (voltage) to gain this required force caused the Counter to operate sporadically. The estimated cost of the system is $34.

Figure 17.4. Event Reminder.
Aluminum Tin Crushing Device For Children With Disabilities

Designers: D. Purdy and C. Spoutz
Supervisor: Bet-tram N. Ezenwa, Ph.D.
Departments of Physical Medicine and Rehabilitation and Mechanical Engineering
Wayne State University Detroit, MI 48202

INTRODUCTION

Persons with disabilities, especially children, always have great psychological benefits when they participate independently in activities of daily living, at school and leisure. Children with disabilities at the Northwest Wayne Skills Center want to take part in crushing and dispensing their lunch tins for recycling. However, their present crusher requires great effort to use and some of the students have limited ability. Their fingers sometimes get entangled during the process of crushing, making it unsafe. The system moves around due to lack of stability. The children and their teachers would like to have a new system to address the following:

Safety - The fixture must be safe for the user as well as others nearby; Easy to operate - The fixture should be simple to operate and require minimal strength to operate; Easy to repair - The fixture should be easy to repair; Easy to duplicate - The fixture should be easy to reproduce in the event that more are desired in the future.

SUMMARY OF IMPACT

The purpose of this project is to design and produce a fixture or jig that allows children with disabilities to crush aluminum lunch tins in preparation for recycling. The jig they currently use is unsafe, and in general, makes the task rather difficult for them to perform. The students typically have limited strength and no fine motor skills.

A system was developed to crush tins with minimum force, and prevent fingers getting in the way during tin crush action. The new system made it possible for a variety of children to participate.

TECHNICAL DESCRIPTION

The design illustrated in Figure 17.5 concentrated on a manually operated system in which the user must have gross reach and grasp abilities, as well as a small degree of physical strength. The fixture consisted of two plates with a surface area equal to or greater than that of the tin itself. The fixture is secured on the table. This is partially accomplished by the fact that the entire piece of equipment has a large mass. The equipment must be safe not only for the user, but also to those around the equipment. This is accomplished by the use of shields on the sides of the plates that cover the entire crush zone. The front edge of the plate consisted of a chamfer to prevent fingers from getting pinched. The specific feature that allowed the user to easily crush the tins is the length of the handles; up to 18 inches maximum is used to maximize the moment arm. The handles are also adjustable to individual user’s abilities. In addition, the top plate of the fixture has a large mass, lowering the crush force. The top plate is easily lifted with the aid of a single centered spring that has enough force to assist in lifting, yet not hamper crushing. The spring force is obviously a critical portion of the design, as it must provide a delicate balance. The handle function is also twofold, it acts also as a safety feature in that the shear length of the handle prevents the user from getting too close to the crush zone while the handle is being pushed down.

A finite element analysis was done on some of the components in the assembly to determine whether or not they are feasible and/or optimal for their particular application. The analysis is done based on part geometry and material selection. Since at this point, actual stresses are unknown, the analysis was performed using a unit load. As expected, there is a potential high stress area at the pivot location. The results of the analysis are intended to show areas of potential high stress, and modifications may then be made to the material and/or part design. Engineering analysis is conducted to determine the spring constant to support the upper part of the system and the lever arm. The constant supports the load on it, and at the same time, soft enough to require a minimum force to lower the load on it. The value is 2 lb./in.
Lever arms are provided to increase the mechanical advantage of the system.

Testing was conducted to ensure the design requirements had been met and the fixture is functioning properly. Tins are crushed to obtain a qualitative evaluation and determine if the required efforts are acceptable. The efforts are found acceptable for crushing the tins. It is also determined that the lifting function provided by the spring adequately assisted in lifting the top plate; yet did not significantly increase required crush loads. Furthermore, the safety features were evaluated and determined to be significant enough to prevent the user or others nearby from injuring themselves.

The overall evaluation of the fixture is that it is functional and acceptable for use by the target group. The estimated total cost of the device is $56.
INTRODUCTION
In the early stages of recovery, patients suffering from severe traumatic brain injury (TBI), usually stay confined to wheelchairs and are allowed to ambulate using leg propulsion. These patients sometimes have a tendency to rock from side to side while in their wheelchairs, producing a rocking motion that causes them and standard wheelchairs to tip over on their sides. The TBI Service Line Manager at the Rehabilitation Institute of Michigan requested an anti-tipping mechanism for one of the patients that make it impossible for the patient to capsize a wheelchair.

SUMMARY OF IMPACT
Further injuries to the head of TBI patients could slow or prevent the recovery process for the patient. It may even cause death. The aim of the project is to develop a system that makes it impossible for the patient to tip sideways during wheelchair-seated leg propelled ambulation, and to make the hallways usable by others.

A system was developed that is practical and usable along the hallway of a hospital. It also has the features that allowed adaptation to other uses.

TECHNICAL DESCRIPTION
The optimal control parameter in this design is the center of gravity (C of G) of the combined human and wheelchair system. Since there are systems to resist near tipping, and the user’s legs prevent front tipping, the design concentrated on side-to-side tipping which solves the problem requested.

Apart from complexity, cost and repeatability, a major constraint is how far a support extends beyond the wheelchair side-to-side dimensions and still allows others to pass freely along standard hospital hallways.

Sideways overturn of a seated wheelchair occurs when the side-to-side input force causes the C of G of the combined system to fall outside the wheelchair base.

The design consideration is to absorb the input forcing function and provide restoring force so that the C of G of the combined system is always inside the wheelchair seat base.

Using the concept that three points make a plane, it was determined that the best way to prevent the chair from tipping on either side in using two extra supports, one in the front, and the other in the rear of each side of the chair.

The implemented system is shown attached to a wheelchair in Figure 17.6. Front anti-tipping consists of two pieces of modified aluminum tubing cross-member. The aluminum tubes, joined by a single bolt, allow the assembly to collapse when the wheelchair folds. Inserts consisting of two .25 inch holes drilled perpendicularly to the radius, are placed on the top of the wheelchairs bottom rail and bolted to a fastener in order to secure the cross-member and remaining components to the wheelchair.

Aluminum u-shaped brackets are welded onto the cross-member, with two .25 inch holes drilled into each side to help secure the cross-member and remaining components to the wheelchair. One end of a steel L-shaped (90-degree) alloy steel is used to connect to the cross-member and the other end is connected to an adjustable leg. At the push of a button, a 90-degree tube rotates 180 degrees. It can be moved in and out for clearance purposes.

The 90 degree tube, which could make contact with the ground, incorporates a spring mechanism to counteract the forces established when tipping occurs. The spring benefits the user in two ways. First, it works as an energy collector when the leg of the anti-tip device is resisting the quick moment, and assists the reaction time to re-stabilize the chair in its upright position.

A flat, thin aluminum V-shaped spring placed inside the 90-degree tube in two locations. When pushed, the springs allow the 90-degree tube and the adjust-
able leg to release from their current position and move to a new position if desired.

Steel components that consist of two half circles or "C's" joined together by two bolts, form a collar, secured onto the wheelchair's bottom rail in the front and rearward of the fastener prevent lateral movement of these components.

Rear is similar to front anti-tipping except for the L-shaped 90-degree component. The tubing slides into the wheelchairs rear bottom rail, and a spring button fastens the tube to the rail. The 90-degree tube can rotates out of the way for clearance and fold in by pressing the spring button. The 90-degree tube also provides the resistance for the tipping moment.

When the front and rear support system are manufactured and assembled, the system performed as designed. Tests were conducted with one of the students in the design group, it has not been tested with an actual TBI patient. The estimated cost of the system is $40.

Figure 17.6. Wheelchair Anti-Tipping Mechanism.